PATENT SPECIFICATION

626,866

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PROVISIONAL SPECIFICATION

Improvements relating to Apparatus for use in Carrying out Chemical Reactions

We, ANGLO-IRANIAN OIL COMPANY LIMITED, of Britannic House, Finsbury Circus, London, E.C.2, a British joint-stock Corporation, and RICHARD ORD JUDD, of the Research Station of the Anglo-Iranian Oil Company Limited, Chertsey Road, Sunbury-on-Thames, of British Nationality, do hereby declare the nature of this invention to be as follows:—

The invention relates to a process and apparatus for carrying out exothermic or endothermic chemical reactions, in which a solid catalyst is employed, and in which it is necessary to control temperature within narrow limits.

Typical reactions of the kind referred to include those involved in the Fischer-Tropsch process for production of hydrocarbons from mixtures of carbon monoxide and hydrogen, and in batch catalytic cracking processes; but the invention is of wide application.

In order to ensure the necessary temperature control, the apparatus used in carrying out the process should provide that the reaction zone be in contact with a zone containing a heat exchange medium, whereby the temperature in the reaction may be controlled. A common form of apparatus for the purpose comprises a number of tubes containing the catalyst, through which tubes the reactants are caused to pass, the tubes being located within a chamber containing the heat transfer medium.

The Applicants have found that such reactions are very efficiently carried out if the catalyst mass be so disposed that the distance of any point therein from a heat exchange surface does not exceed a determined maximum. The use of apparatus in which tubes contain the catalyst is therefore limited to tubes having an internal diameter equal to twice that maximum, if effect be given to the condition referred to, with the consequence that in many cases an inconveniently large number of tubes is required, and the construction of the apparatus is thus rendered difficult and costly.

The invention has among its objects to use for such reactions an apparatus and process conditions in which the difficulties presented in the use of known tubular types of apparatus are avoided.

According to the invention one or more open-ended catalyst chambers or receptacles are employed, advantageously rectangular in transverse cross-section, and located within a heat exchange vessel, through which circulates a liquid or gaseous heat exchange or transfer medium, under conditions in which the processing temperature within the reaction chamber or reaction chambers may thus be controlled.

According to the invention moreover the catalyst reaction chambers or receptacles are disposed in series across the heat exchange vessel, and the reaction chambers or receptacles separated by intermediate co-extensive spaces serving as channels through which the liquid or gaseous heat exchange or transfer medium may pass.

According to the invention moreover the catalyst chambers or receptacles that may be disposed in horizontal and vertical series within the heat exchange vessel are constructed of pairs of lateral walls spaced apart and held in parallel and aligned relation by transversely disposed connecting sleeves mounted and held as by welding the shouldered ends of the respective sleeves to the upper and lower ends of the lateral walls of adjacent chambers.

According to the invention moreover the vertical series of catalyst receptacles thus constructed as units are mounted within a heat exchange vessel that advantageously is of a cylindrical form and set endwise upstanding in the position of use, being so disposed in units as to provide intermediate spaces between them.

According to the invention moreover

an annular space is provided within the heat exchange vessel surrounding the assembly of units, that may advantageously be disposed in parallel relation, and separated by intermediate spaces between which the circulation of gas is maintained.

According to the invention moreover in order more completely to utilise the area available within the cylindrical heat exchange vessel, the units may have different dimensions horizontally to accommodate the circular curvature of the cylindrical heat exchange vessel and thus also to provide a continuous annular space within the vessel to surround the assembly of units.

According to the invention moreover the transversely disposed connecting sleeves are reduced in diameter and held as by welding their shouldered ends to the oppositely disposed lateral walls of the respective catalyst receptacles. Such disposition and connection of the parts is adapted to resist internal and external pressure upon the lateral walls of the catalyst receptacles, while the circulation of the heat exchange or transfer medium is increased within the heat exchange or transfer vessel by the transversely disposed tubular sleeves passing through the catalyst receptacles, and through intervening spaces between the respective units and the annular space surrounding the assembly of parallel disposed units within the heat exchange vessel.

The invention comprises the constructional features hereinafter described.

In carrying the invention into effect according to one embodiment of the invention, the apparatus may consist of a pressure resistant vessel, that advantageously may be provided of a cylindrical and elongated form. Top and bottom cover plates are mounted at the respective ends of the pressure resistant vessel, and may be respectively secured to flanges at the respective ends of the vessel by bolts, the top cover plate being drilled centrally for the reception of the end of a gas inlet pipe, while the bottom cover plate is similarly provided for the connection of a gas outlet pipe.

A series of vertical catalyst chambers or receptacles of elongated rectangular cross-section is provided within the pressure resistant vessel by means of rectangular plates, each chamber or receptacle being constituted of two opposed rows of plates that at the upper and lower end of the units are welded into slots in the circular end cover plates, which are themselves welded to the inner face of the peripheral wall of the pressure resistant vessel. The plates are secured to each other along their abutting vertical edges, the exposed vertical edge being secured to semi-circular sections which are likewise welded at their ends into slots in the end cover plates.

The slots in the end cover plates extend completely through the cover plates so that a series of open-ended chambers or receptacles spaced apart are provided for the reception of the catalyst used in the reaction, the reactants entering and leaving the chambers or receptacles through the open ends thereof.

End cover plates of determined dimensions may be employed to ensure that no particle of catalyst is more than a determined distance from an internal surface of the chamber or receptacle.

The pressure resistant vessel is provided with connections for the supply of the heat exchange fluid, which flows past and between the catalyst chambers, and also with a purging vent. Thus the heat exchange fluid may pass into the lower end of the annular space surrounding the units and may pass through an outlet at the upper end.

The liquid or gaseous heat transfer medium may pass into the annular space surrounding the units at the upper end in position beneath the top cover plate.

In order to maintain the desired separation of the side walls of the catalyst chambers or receptacles, hollow sleeves are employed as hereinbefore described, which serve as spacing and strengthening members that extend across the walls of the catalyst chambers or receptacles as hereinbefore described, the ends of the sleeves being advantageously flush with the external surface of the walls of the receptacles, and welded thereto. The sleeves are advantageously of uniform bore, and are reduced in thickness at their ends to form shoulders for engagement with the walls of the catalyst receptacles. By such means support against pressure inwardly or outwardly of the walls of the catalyst receptacles, is provided. Thus in operating the process, if pressure within the catalyst receptacle is substantially greater than that to which the receptacle is externally subjected, the sleeves function as tension members. Otherwise if greater pressure is applied to the outer face of the catalyst receptacle, the sleeves function as struts. The sleeves also serve to increase the circulation of the heat exchange medium, by providing passage through the catalyst receptacle.

The space above the catalyst receptacle units may conveniently serve for mounting a pre-heater or auxiliary heater, whereby the reactants may be conveniently heated prior to the entry into the catalyst receptacle or for effecting the re-

duction *in situ* of catalysts requiring such treatment before use.

Dated this 14th day of August, 1946.

EDWARD EVANS & CO.,
14—18, High Holborn, London, W.C.1,
Agents for the Applicants.

COMPLETE SPECIFICATION

Improvements relating to Apparatus for use in Carrying out Chemical Reactions

We, ANGLO-IRANIAN OIL COMPANY LIMITED, of Britannic House, Finsbury Circus, London, E.C.2, a British joint-stock Corporation, and RICHARD ORD JUDD, of the Research Station of the Anglo-Iranian Oil Company Limited, Chertsey Road, Sunbury-on-Thames, of British Nationality, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to an apparatus for use in carrying out exothermic or endothermic chemical reactions in which a solid catalyst is employed and in which it is necessary to control the temperature of the reactions within narrow limits.

Typical reactions of the kind referred to include those involved in the Fischer Tropsch process for the production of hydrocarbons from mixtures of carbon monoxide and hydrogen, and in batch catalytic cracking processes.

In order to ensure the necessary temperature control, the apparatus used in carrying out the process should provide that the reaction zone be in contact with a zone containing a heat exchange medium. A common form of apparatus for the purpose comprises a number of tubes containing the catalyst, through which tubes the reactants are caused to pass, the tubes being located within a chamber containing the heat exchange medium.

The Applicants have found that such reactions are efficiently carried out if the catalyst mass be so disposed that the distance of any point in the mass from a heat exchange surface does not exceed a determined maximum. The use of apparatus in which the catalyst is contained in tubes is therefore limited to tubes having an internal diameter equal to twice the determined maximum, if effect be given to the condition referred to, with the result that in many cases an inconveniently large number of tubes is required, and the construction of the apparatus is thus rendered difficult and costly.

The invention has among its objects to provide an apparatus for use in carrying out such reactions in which the difficulties presented in the use of known tubular types of apparatus are avoided.

According to the invention, the apparatus comprises one or more open-ended catalyst chambers of elongated rectangular cross-section, the chamber, or each of the chambers, consisting of a pair of side walls secured to end walls and spaced apart by means of transversely disposed tubular members secured at their ends to the side walls so as to form transverse passages through the chamber, the chamber or chambers being located within a vessel through which circulates a heat-exchange medium.

Advantageously the side walls of the catalyst chambers may consist of rows of vertical plates that are secured to each other at their abutting vertical edges, the exposed vertical edge of each end plate being secured to one of the end members. The tubular spacing members may conveniently be located along the junctions between pairs of said plates, and may be of uniform bore but are advantageously formed with end portions of reduced external diameter to form shoulders adapted to abut against the inner faces of the side walls.

According to a further feature of the invention the catalyst chambers may be disposed in series across the heat exchange vessel and may be separated by intermediate co-extensive spaces serving as channels through which the heat exchange medium passes. An annular space may be provided within the heat exchange vessel to surround the assembly of units which may advantageously be disposed in parallel relation within the heat exchange vessel.

The invention will now be described with reference to the accompanying drawings which illustrate one example of carrying out the invention, in which:—

Figure 1 is a vertical section through the apparatus,

Figure 2 is a corresponding plan view with the top closure member removed,

Figure 3 is a transverse cross-section through an individual catalyst chamber, and

Figure 4 is a fragmentary perspective view of the catalyst chamber.

The apparatus comprises a pressure-resistant vessel 10, of cylindrical section. Top and bottom cover plates 11 and 12 respectively for the vessel 10, are secured to annular flanges 13, provided at each end of the vessel, by means of bolts 14 extending through the flanges. The top cover plate 11 is drilled centrally for connection to the end of a gas inlet pipe 15, while the bottom cover plate 12 is similarly drilled for connection to a gas outlet pipe 16.

A series of vertical catalyst chambers 17 of elongated rectangular cross-section is mounted within the vessel 10. Each chamber 17 consists of two oppositely disposed and parallel rows of plates 18 that are welded together at their abutting vertical edges, and at the ends the exposed vertical edge of each plate being welded to semi-circular sections 19, thereby forming a series of open-ended chambers for the reception of the catalyst mass.

In order to maintain the desired spacing between the side walls of the chambers 17, sleeves 20 are provided extending transversely between the walls so as to form passages 21 through the chambers 17. The sleeves 20 are provided of a reduced external diameter at the ends to form shoulders 22 for locating the walls of the chambers 17 in the sleeves 20. The sleeves 20 are welded as at 23, to pairs of adjacent plates 18. The dimensions of the sleeves 20 are such that the ends of the sleeves lie flush with the external surface of the side walls of the chambers 17, while the distance between the internal wall surfaces is equal to twice the maximum distance that a catalyst particle may be from a cooling surface.

The assembly of catalyst chambers 17 is secured in position within the vessel 10 by being welded at the end rows of the chambers in slots or grooves 24, provided in circular end plates 25 which are themselves welded at their peripheries to the inner peripheral surface of the vessel 10 as indicated at 26, to leave spaces at the ends and an annular space 27 around the chambers 17. The slots 24 lie parallel with narrow passages 28 between the chambers 17.

The vessel 10 is provided at the lower end with an inlet 29, and at the upper end with an outlet 30 for the heat exchange fluid, at which position there is also provided a purging vent 31.

In using the apparatus as above described for carrying out a chemical reaction in which it is necessary for the temperature to be carefully controlled, the reactants are admitted to the vessel 10 through the inlet pipe 15 and flow downwardly through the open-ended catalyst-filled chambers 17 in which the reaction proceeds, the reaction products leaving the vessel 10 through the outlet pipe 16. Heat exchange fluid is admitted to the vessel 10 through the inlet 29, passes around and between the side walls of the chambers 17 and also transversely thereto by way of the passages 21, and leaves the vessel 10 through the outlet 30.

The arrangement of the catalyst chambers with transversely extending sleeves, as above described, provides support against pressure inwardly or outwardly on the walls of the chambers. Thus, if pressure within the chambers is substantially greater than that to which the chambers are externally subjected, the sleeves function as tension members: if greater pressure is applied to the outer faces of the chambers, the sleeves function as struts.

The space above the catalyst chambers 17 may conveniently serve for mounting a pre-heater or auxiliary heater for heating the reactants prior to their entry into the chambers, or for effecting the reduction *in situ* of catalysts requiring such treatment before use.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for use in carrying out catalysed chemical reactions, comprising one or more open-ended catalyst chambers of elongated rectangular cross-section, the chamber or each of the chambers consisting of a pair of elongated parallel side walls secured to end members and maintained in spaced relation by means of transversely disposed tubular members secured at their ends to the respective side walls so as to form transverse passages through the chamber, and the chamber or chambers being located within a vessel adapted for the circulation therethrough of a heat exchange medium.

2. Apparatus according to claim 1, wherein the side walls consist of rows of vertical plates that are secured to each other at their abutting vertical edges, the exposed vertical edge of each end plate being secured to one of the end members.

3. Apparatus according to claim 2, in which the tubular spacing members are located along the junctions between pairs of the plates.

4. Apparatus according to any of the preceding claims, in which the tubular members are of uniform bore but are formed with end portions of reduced external diameter to form shoulders adapted to abut against the inner faces of the side walls.

5. Apparatus according to any of the preceding claims, in which the catalyst chambers are disposed across the heat exchange vessel and are separated by intermediate co-extensive spaces serving as channels through which the heat exchange medium passes.

6. Apparatus according to claim 5, in which an annular space is provided within the heat-exchange vessel and surrounding the assembly of units.

7. Apparatus according to claim 5 or claim 6, in which the catalyst chambers are disposed in parallel relation within the heat exchange vessel.

8. Apparatus according to any of the preceding claims, in which the catalyst chambers are secured at their ends in slots in end covers within the heat exchange vessel.

9. Apparatus according to any of the preceding claims, in which the heat exchange vessel is provided with means for the admission of reactants to the catalyst chambers and means for the removal of the reaction products from the catalyst chambers.

10. Apparatus according to any of the preceding claims, in which the heat exchange vessel is provided with means for the admission and removal of a heat exchange medium.

11. Apparatus for use in carrying out catalysed exothermic and endothermic chemical reactions substantially as herein before described with reference to the accompanying drawings.

Dated this 13th day of August, 1947.
EDWARD EVANS & CO.,
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Agents for the Applicants.

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SHEET 1

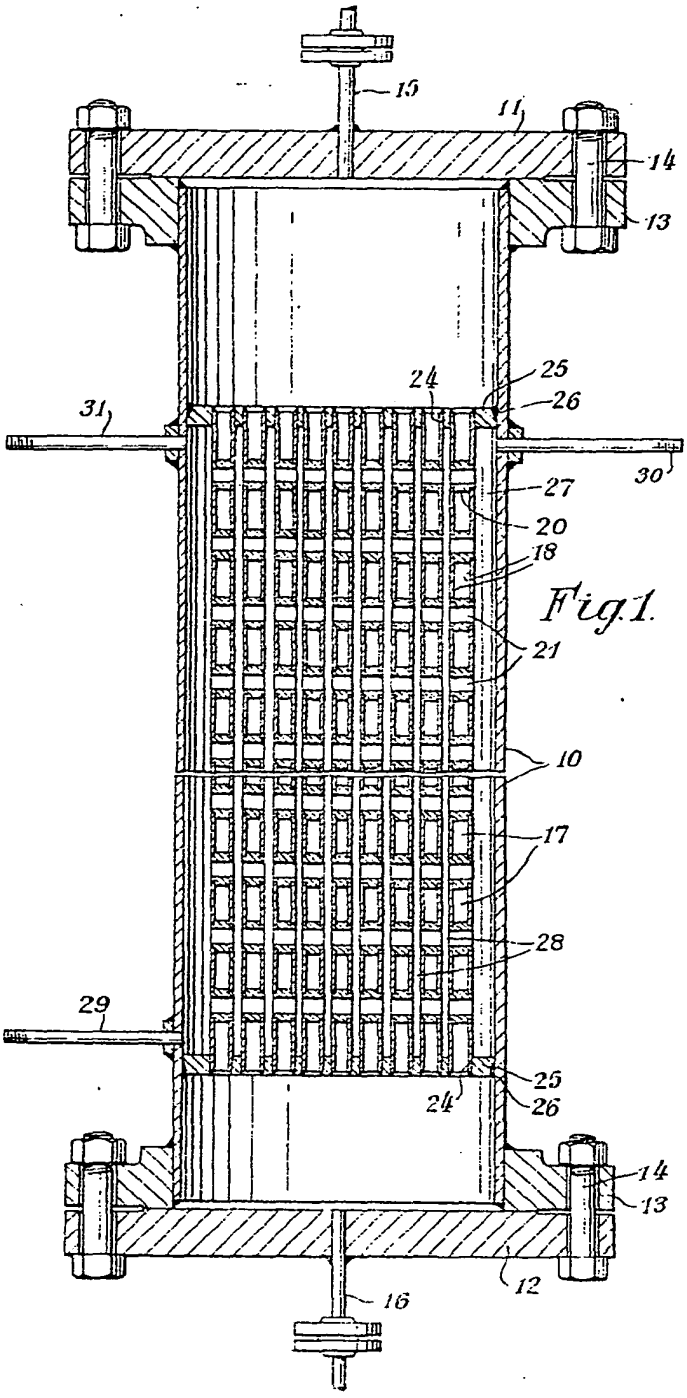

Fig.1.

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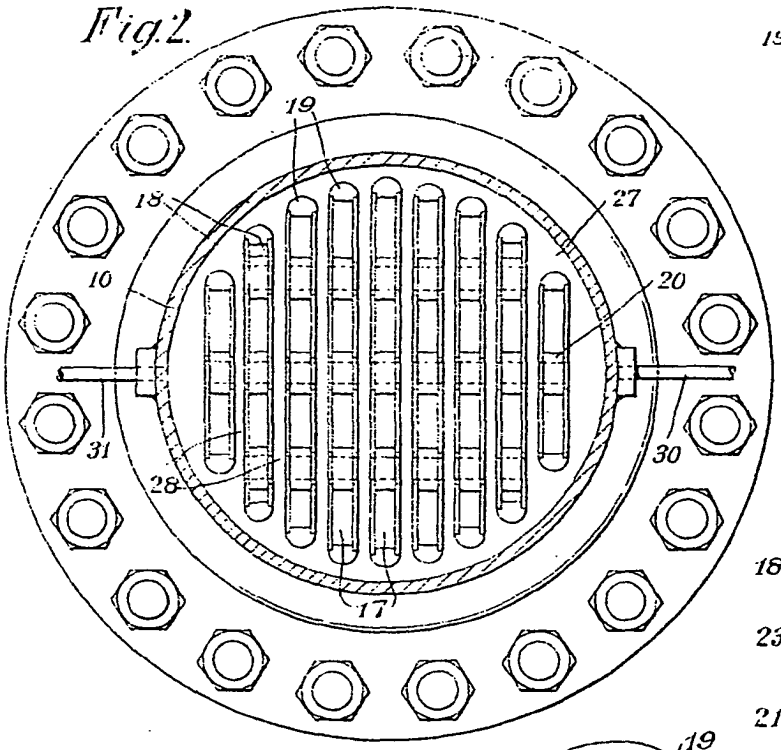
Fig.2.



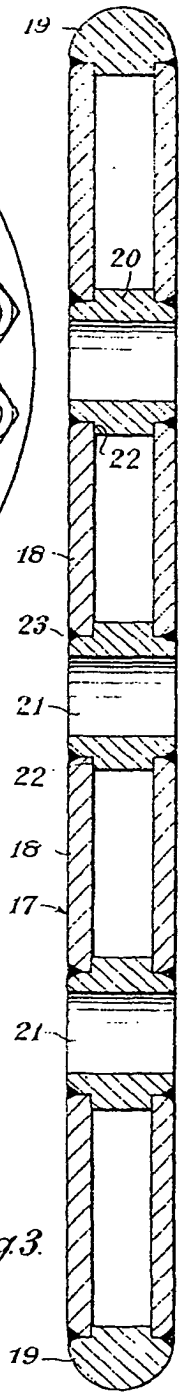
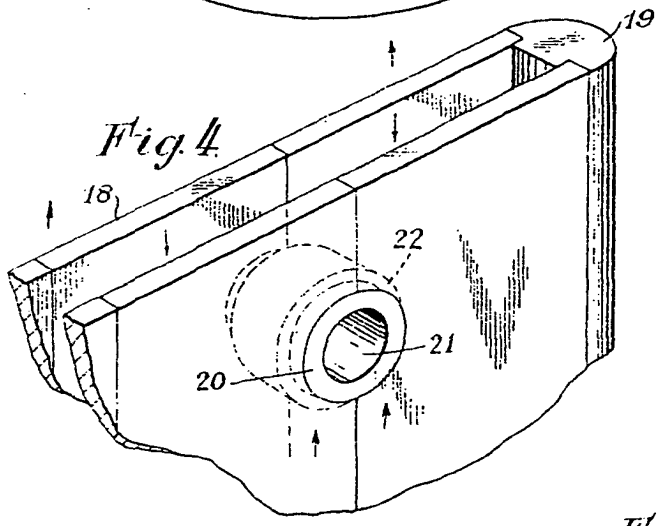


Fig.3.

Fig.4.



H.M.S.O. (Ty. P.)

626,866 COMPLETE SPECIFICATION

2 SHEETS

SHEET 1

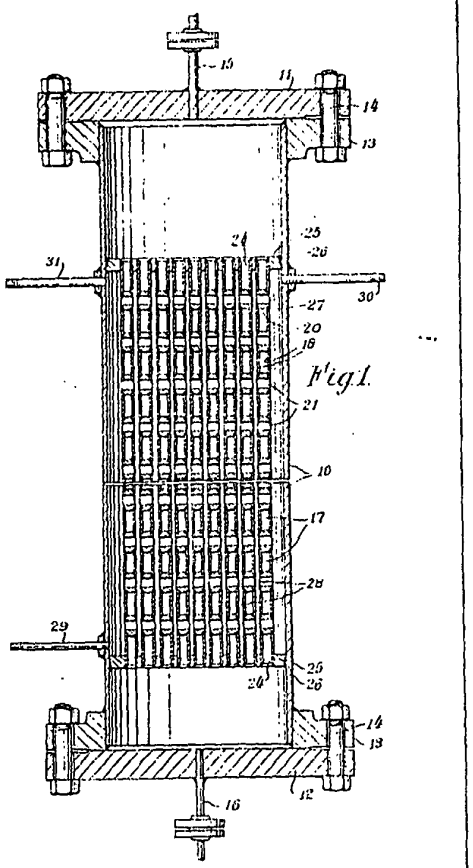


Fig. 1.

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SHEET 2

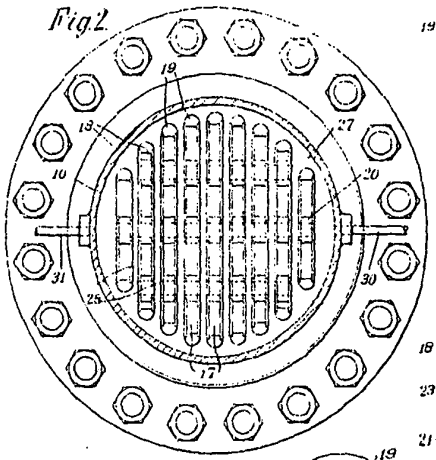

Fig. 2.

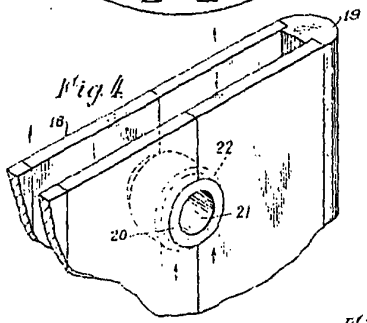

Fig. 4.

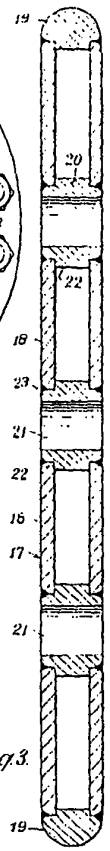

Fig. 3.

H.M.S.O. (Ty. P.)